MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ERT3046 – MACHINE VISION

(RE)

24 OCTOBER 2017
2.30 p.m – 4.30 p.m
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question Paper consists of 6 pages with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

QUESTION 1

a) A company produces a line of electronic components for wireless phones. Stringent quality requirement shows 100% visual inspection. At the inspection station, a robotic mechanism is used to place each electronic component over a lighting located under an optical system to magnify for inspection. The image fills the viewing screen of size 80 mm by 80 mm. Defects appear as grey spots, and inspection's job is to study at the screen and reject samples that have one or more grey spots with diameter of at least 0.8 mm.

After the investigation, the supervisor decides to view each inspection by CCD TV camera. The inspection requirement is to find the small defect area of 2 by 2 pixels from the digital image. For the camera, the possible resolutions are 512 by 512, 1024 by 1024, and 2048 by 2048 with respect to 25mm, 35mm, and 200 mm respectively. The individual imaging elements in the cameras are squares measuring 8 μm x 8 μm, and the spaces between imaging elements are 2 μm. For this application, the camera cost is much more than the lenses. As an engineer, provide a written recommendation with analysis on how to choose the right resolution so that cost-saving can be more effective. [15 marks]

b) With reference to Figure Q1, the closing of binary image A by structure element S is denoted by $A \bullet S$ and the opening of binary image A by structure element S is denoted by $A^{\circ}S$.

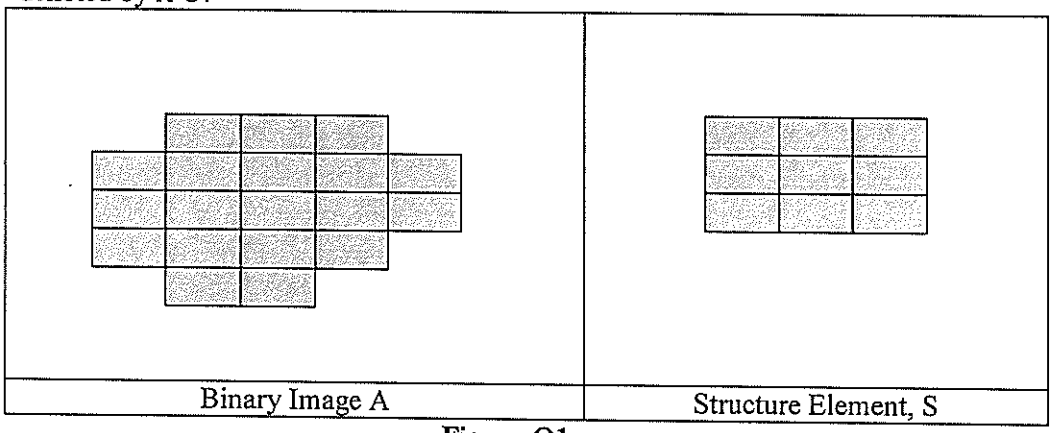

Figure Q1

(i) Apply the morphological *erosion* of binary image A of **Figure Q1** using structure element (S). [2 marks]

(ii) Apply the morphological *dilation* of binary image A of **Figure Q1** using structuring element (S). [2 marks]

(iii) From the result of (i), apply the morphological *opening* using structure element (S). [3 marks]

(iv) From the result of (ii), apply the morphological *closing* using structure element (S). [3 marks]

Continued...

QUESTION 2

a) The principal objective of sharpening is to highlight fine details in an image or to enhance details that have been blurred, either in error or as a natural effect of a particular method of image acquisition. Uses of image sharpening vary and include applications ranging from electronic printing and medical imaging to industrial inspection and autonomous target detection in smart weapons. Elaborate the working principles of the two sharpening filters.

(i) Spatial Highpass Filter [3 marks]

(ii) High-boost Filtering [3 marks]

b) In a photographic camera, the lens has a fixed focal length. The focusing at distance is achieved by changing the distance between the lens and the imaging plane. In the human eye, the distance between the lens and imaging region (the retina) is fixed. The focal length needed to achieve proper focus is obtained by changing the shape of lens.

Propose the right diameter range of the smallest printer dot so that the eye can discern of the paper page on which the printer black dot is 0.3 meter away from the eyes. In geometric terms, assume that visual system stops to detect the dot when the image of the dot on the fovea becomes smaller than the diameter of one receptor in the area of retina. The fovea can be modelled as a circular array of diameter 3 mm; the cones and spaces between the cones are distributed uniformly throughout the array with array of size 600 by 600 elements (pixels). [10 marks]

c) Perform the output pixel values (on the inner 6 × 6 part) on the segment 8-bits digital image shown in **Figure Q2** after it is filtered by a 3 × 3 Prewitt mask. [9 marks]

0	0	0	0	100	100	0	0
0	0	0	0	100	100	100	200
0	0	100	0	0	0	0	0
0	0	0	0	0	0	90	80
0	0	0	0	250	150	100	150
0	30	0	0	230	230	230	230
0	0	0	0	250	230	230	230
0	0	0	0	0	0	0	0

Figure Q2

Continued...

QUESTION 3

(a) Relate "Freeman chain code" and state two disadvantages of this chain code. [6 marks]

(b) The gray level co-occurrence matrix $P[i,j]$ is defined by first specifying a displacement vector $d = [dx, dy]$ and counting all pairs of pixels separated by d having gray levels i and j based on the image shown in **Figure Q3b**.

(i) Create the co-occurrence matrix for displacement $d = [0,0]$. [4 marks]
(ii) Create the co-occurrence matrix for displacement $d = [1,0]$. [4 marks]
(iii) Analyze the entropy and the energy levels for the co-occurrence matrix obtained for displacement $d = [0,0]$. [4 marks]

1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1

Figure Q3b

(c) **Figure Q3c** shows the contour of an object indicated by the dark pixels. Perform the 8-direction Chain Code of the contour starting from pixel A in clockwise direction (x is the starting point).

(i) Construct the chain code for **Figure Q3(c)** after rotated 180^0 clockwise direction. [4 marks]

(ii) Construct the chain code for Figure Q3(c) after rotated 270^0 in clockwise direction. [3 marks]

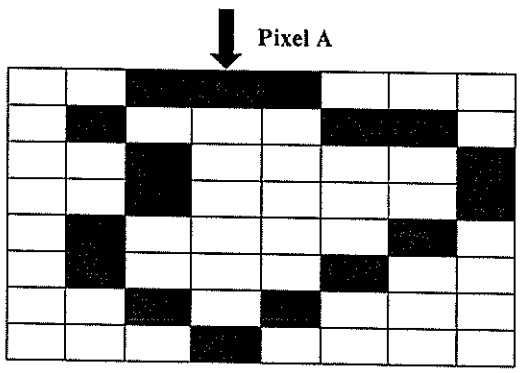

Figure Q3c

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QUESTION 4

a) For a machine vision system, the ability to cope with moving and changing objects, changing illumination, and changing viewpoints is important to perform tasks. Although early computer vision systems were concerned primarily with static scenes, computer vision systems for analyzing dynamic scenes are being designed for different applications. The input to a dynamic scene analysis system is a sequence of image frames taken from a changing world. The camera is then used to acquire the image sequence may also be in motion. Each frame represents an image of the scene at a particular instant in time. There are three phases of dynamic vision analysis. Discuss and break down the three phases. [6 marks]

b) **Table Q4-1** shows **THREE (3)** classes (**Class X, Y, and Z**) which are classified through their extracted features represented by points in 2-dimensional space.

(i) Analyze to which **class M** is classified into by using 5-nearest neighbour class. (*Use Euclidean distance as the distance metric)* [10 marks]

(ii) Plot the graph for the **THREE (3)** classes for feature extraction. [3 marks]

Table Q4-1

Class X

Axis	x-axis	y-axis
point1	0.56	0.4
point2	0.66	0.35
point3	0.61	0.28
point4	0.71	0.35
point5	0.66	0.38

Class Y

Axis	x-axis	y-axis
point1	0.32	0.3
point2	0.36	0.25
point3	0.38	0.11
point4	0.41	0.19
point5	0.44	0.26

Class Z

Axis	x-axis	y-axis
point1	0.25	0.55
point2	0.33	0.46
point3	0.28	0.41
point4	0.21	0.34
point5	0.38	0.51

Class M

Axis	x-axis	y-axis
point	0.54	0.42

c) **Figure Q4c** shows a confusion matrix for a character recognition problem attempting to classify characters from 'A' to 'G'. Altogether, there are 700 feature vectors used to represent 700 alphabets. 'R' indicates 'reject' class. From the confusion matrix,

(i) Analyze the error rates for all the inputs. [3 marks]

(ii) Analyze the reject rate for the classifier. [3 marks]

Continued...

Class j output

True Object Class i	'A'	'B'	'C'	'D'	'E'	'F'	'G'	'R'
'A'	98	1	0	0	0	1	0	0
'B'	0	96	0	2	1	1	0	0
'C'	0	0	93	1	2	0	4	0
'D'	0	1	0	97	0	0	1	1
'E'	0	1	2	0	95	2	0	0
'F'	0	0	0	0	2	96	0	2
'G'	0	0	3	0	0	0	97	0

Figure Q4c

End of Paper